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THE BENTHIC POLYCHAETA AND AMPHIPODA OF MORRO BAY, CALIFORNIA

By Donald J. Reish and J. Laurens Barnard[1]

This paper records the present fauna of polychaete worms and amphipod crustaceans of Morro Bay, California, and reports upon their zoogeographic relationships to areas previously studied by the authors. Prior work in Morro Bay includes a study of the distribution of the wood-boring isopod *Limnoria* and the Nebaliacea (Menzies and Mohr, 1952) and amphipods (Barnard, 1952).

Although altered by dredging, the installation of wharfs, and the establishment of oyster farming, the environment of Morro Bay is of interest because of the sparsity of other embayments on the long coastline of central California. Previous studies on the benthic invertebrates of Californian bays and harbors include the following: Tomales Bay (Pitelka and Paulson, 1962), San Francisco Bay (Packard, 1918; Hartman, 1954a; Filice, 1954, 1958, 1959; Jones, 1961), Elkhorn Slough (MacGinitie, 1935), Los Angeles—Long Beach Harbors (Reish, 1959b), Alamitos Bay (Reish and Winter, 1954; Reish, 1961, 1963a), Newport Bay (Barnard and Reish, 1959), San Diego Bay (Anon., 1952), and Catalina Harbor, Santa Catalina

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Island (Reish, 1964). All of these Californian embayments have been altered to some extent by man so that the aboriginal faunas are unknown; presumably the biotas have been modified by the introduction of cosmopolitan bay forms (Barnard, 1961), by means of shipping, oyster culture, and other transmitting agents.

Description of Morro Bay.—Morro Bay (fig. 1) lies on the southern middle portion of the California coast, just north of the

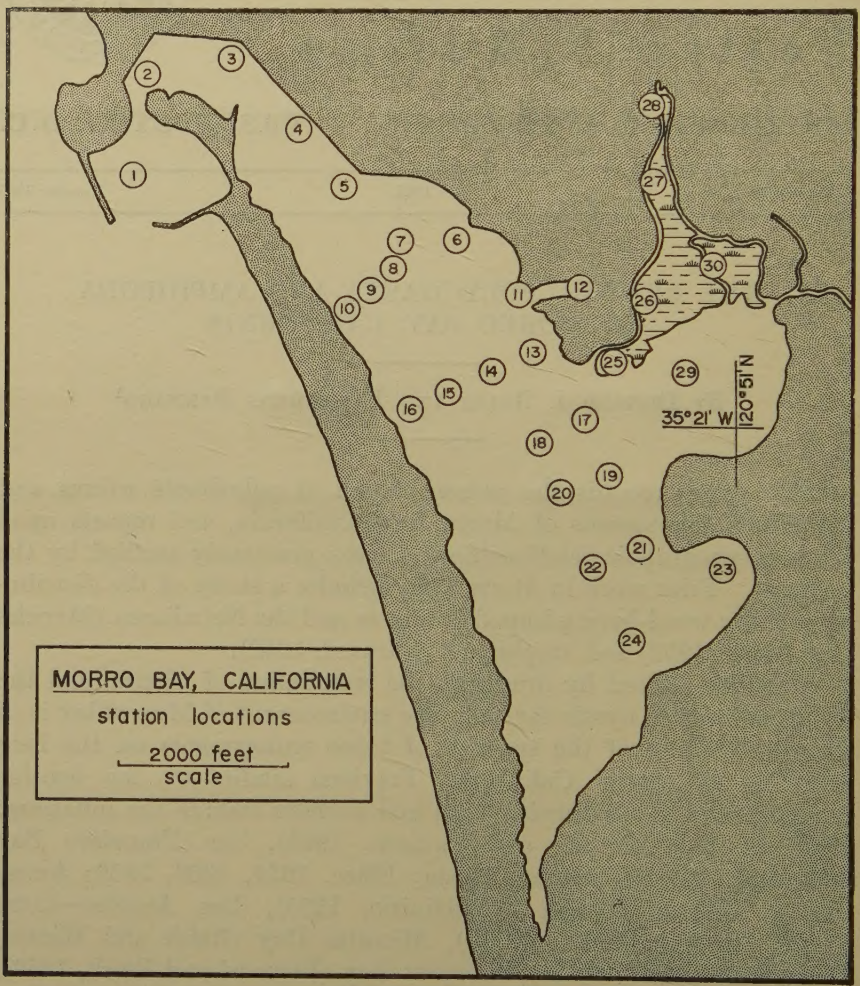

Figure 1.—Station locations of benthic survey, August 25, 1960.

zoogeographical boundary of Point Conception. Open-sea water temperatures approximate the southernmost extension of cold-temperate conditions and the rainfall is sufficient to permit a slight dilution of bay waters. This situation is in contrast to the embay-

ments south of Point Conception that belong with the warm-temperate, low-rainfall regime.

Except where dredging has deepened some channels, Morro Bay is exceedingly shallow; much of the bay floor is exposed during minus tides. Two streams drain into the bay: Chorro Creek enters the Bay through a channel in the marshland (Stations 28 to 25) and Los Osos Creek enters near Station 29. The triangular marshland, extending from Stations 28 to 25 and then landward to the right in figure 1, constitutes the Morro Bay State Park Bird Reserve. Changes by man in Morro Bay include the dredging of channels, the construction of a small boat harbor at Stations 11 and 12, dock facilities along the shore extending from about Stations 3 to 11, jetties at the Bay entrance, and fencing for oyster beds. Small docks have been built at other localities of the bay. No pollution is known to exist (Barrett, 1963). A steam-generating plant near Station 3 takes in sea water from this area for use in cooling condensors, but the water is discharged by a channel into the open sea north of the Bay.

Although Morro Bay is important as a port for both commercial and sport fisheries, only the oyster, accounting for a value of $24,467 in 1961, is harvested directly from the bay. The total value of commercial landings for 1961 (Anon., 1963) was $632,324, with abalone accounting for over one-third of the total. The history of oyster farming in Morro Bay has been summarized by Barrett (1963). The Pacific oyster, *Crassostrea gigas* (Thunberg), was first introduced from Japan to Morro Bay in 1932. The beds extend throughout much of the middle part of the bay from about the region of Station 5 to Stations 21, 22, and 29 (fig. 1).

Materials and methods.—Bottom samples, taken on August 25, 1960, from a small skiff using a size one Hayward orange-peel bucket (taking an area of $\frac{1}{16}$ sq. meter), were obtained from all stations indicated in figure 1 with the exception of Stations 1, 2, 5, and 6 where the substrate was a hard-packed sand. The samples were washed on shore through a size 24 screen (0.7 mm openings) and preserved in formalin diluted with seawater. The polychaetes and amphipods were separated from the other organisms by Mr. Harold Pope. The polychaetes were identified by Reish and the amphipods by Barnard. The dissolved oxygen, salinity, and water temperature were determined on August 26, 1960, from 14 representative stations at surface and deeper levels; each varied according to depth of water. The modified Winkler method was used for dissolved oxygen measurement (Barnes, 1959), and the chlorinity was determined by the Mohr method (Barnes, 1959). Water temperature was measured with a thermistor-type thermometer.

Chemical and physical data.—Chlorinity was that of normal sea water throughout the sampled areas of Morro Bay. The chlorinity probably is lowered in the vicinities of Chorro and Los Osos Creeks during the winter rainy season.

Dissolved oxygen of the water ranged from 4.2 to 7.1 ppm with the lowest value measured at Station 10 and the highest at Station 25. The oxygen values of the deeper waters were generally slightly higher than those of the surface readings.

Temperature of the water ranged from 13.4° to 17.8° C on August 26, 1960. The lower measurements were recorded at the entrance of Morro Bay and the higher values at Stations 23, 25, and 26.

Sediments were not analyzed for particle size, but their condition was noted at the time of collection. In general, the sedimentary characteristics of Morro Bay may be divided into three catagories. Sands predominate at the entrance of the bay and extend to about the region of stations 7 and 8. Fine sediments and extensive patches of eel-grass, *Zostera marina*, and sea lettuce, *Ulva* sp., occur throughout much of the rest of the bay. The sediments of Chorro Creek, especially at Stations 27 and 28, consisted primarily of gravels with a thin layer of silts and fine sands on top.

The Polychaete Fauna

The polychaetes collected from the benthos of Morro Bay are listed in table 1 and are compared with those of other embayments of California and Baja California for which data are available. Of the 34 species taken, 18% or 55% also occur in San Francisco Bay. Less than 50% of the species are common with areas studied south of Morro Bay.

New distributional data are recorded for seven species. The northern distribution is herein extended for three species from southern California, namely, *Prionospio pygmaeus*, *Spiophanes missionensis* and *Pista alata*. *Cossura longocirrata* is extended southward from Vancouver. *Pseudopolydora kempi* is reported from the eastern Pacific Ocean for the first time. With reservation, *Magelona papillicornis* is reported from the Pacific Ocean for the first time. *Chone infundibuliformis* was reported from Elkhorn Slough by Berkeley and Berkeley (1935). No endemic polychaete was found in Morro Bay. *Sphaerosyllis hystrix*, *Typosyllis fasciata*, *Boccardia polybranchia*, and Spirorbinae have not been reported previously from the bay environments in the eastern Pacific Ocean.

Four species account for over 70% of the 9127 specimens of polychaetes collected from the bay: *Capitella capitata* (2434), *Streblospio benedicti* (1999), *Heteromastus filiformis* (1078), and *Exogone lourei*

TABLE 1.—Comparison of the polychaetes from Morro Bay with those from other California bays

Species	San Francisco Bay [1]	Los Angeles Long Beach Harbors [2]	Alamitos Bay [3]	Newport Bay [4]	Catalina Harbor [5]	San Quintin Bay [6]
Anaitides williamsi	X	X	X	X		X
Eteone californica	X	X				
E. dilatae			X	X	X	X
Hypoeulalia bilineata		X				X
Exogone lourei				X	X	
Sphaerosyllis hystrix						
Typosyllis fasciata						
Nereis latescens	X	X				
N. procera	X	X	X	X	X	
Platynereis bicanaliculata	X	X	X	X	X	X
Nephtys caecoides	X	X	X	X		X
Lumbrineris zonata	X					
Stauronereis articulata		X	X	X	X	X
Haploscoloplos pugettensis	X	X	X	X	X	X
Scoloplos acmeceps	X				X	X
Nerinides acuta	X		X	X		
Boccardia polybranchia						
P. ligni	X		X		X	
Prionospio cirrifera	X	X	X	X	X	
P. pygmaeus						X
Pseudopolydora kempi						
Streblospio benedicti	X		X	X		
Spiophanes missionensis		X	X	X	X	X
Magelona ? papillicornis						
Cossura longocirrata						
Ctenodrilus serratus		X				
Armandia bioculata	X	X	X	X		X
Capitella capitata	X	X	X	X		X
Heteromastus filiformis	X					
Axiothella rubrocincta	X	X		X	X	X
Pista alata			X	X	X	X
Chone infundibuliformis						
Spirorbinae						
Number of species in common	18	15	16	16	12	15
Percent in common	55	45	48	48	35	45

[1] Hartman, 1954a; Jones, 1961. [2] Reish, 1959b, 1961. [3] Reish, 1961, 1963a. [4] Reish, 1959a. [5] Reish, 1964. [6] Reish, 1963b.

(886). Of the 26 stations from which polychaetes were taken, *E. lourei* was present at 19, *H. filiformis* at 17, *C. capitata* at 15, and *S. benedicti* at 14.

The community structure of the polychaetes follows the general pattern of the sediment characteristics discussed above. The sandy

fauna is nearest the channel entrance and is dominated numerically by *Armandia bioculata*. The central part of the bay consists of fine sediments and is dominated numerically by *Heteromastus filiformis* and *Exogone lourei*. At individual stations *C. capitata* and *Pista alata* may occur in large numbers and thus alter the community structure. The Chorro and Los Osos Creeks fauna is dominated numerically by *S. benedicti* and *C. capitata*; these two species are known to be tolerant of brackish waters elsewhere (Woodwick, 1953).

Dr. Keith H. Woodwick, Fresno State College, identified the specimens of the genus *Polydora*, sensu lato, for which aid we are grateful.

Family Phyllodocidae

Anaitides williamsi Hartman

Anaitides williamsi Hartman, 1936, p. 126, figs. 33–35.—Reish, 1963b, p. 408.

MATERIAL.—Stations 9(1), 10(6), 11(3), 17(1), 19(1).

DISTRIBUTION.—Oregon to Baja California.

Eteone californica Hartman

Eteone californica Hartman, 1936, p. 131, figs. 43–46; 1961, p. 12.

MATERIAL.—Station 29(11).

DISTRIBUTION.—Central and southern California.

Eteone dilatae Hartman

Eteone dilatae Hartman, 1936, pp. 130–131, figs. 40–42.—Reish, 1963b, p. 408.

MATERIAL.—Stations 8(1), 12(1), 14(4), 16(1), 22(8), 25(14), 26(8), 30(2).

DISTRIBUTION.—Central California to Baja California.

Hypoeulalia bilineata (Johnston)

Phyllodoce bilineata Johnston, 1840, p. 227.
Eulalia bilineata (Johnston).—Pettibone, 1963, pp. 86–88, fig. 20.
Hypoeulalia bilineata (Johnston).—Hartman, 1961, p. 13.—Reish, 1963b, p. 423.

MATERIAL.—Stations 8(1), 11(4).

DISTRIBUTION.—British Columbia to southern California, Nova Scotia to North Carolina, Arctic Ocean, Europe, Japan, and South Africa.

Family Syllidae

Exogone lourei Berkeley and Berkeley

Exogone lourei Berkeley and Berkeley, 1938, pp. 44–47, figs. 6–10.—Reish, 1959b, p. 80.

MATERIAL.—Stations 7(1), 8(1), 9(31), 10(102), 11(7), 12(4), 13(1), 15(17), 16(260), 17(1), 18(18), 19(1), 21(1), 22(308), 23(22), 24(5), 26(2), 29(102), 30(2).

DISTRIBUTION.—British Columbia, California, and Acapulco, Mexico.

Sphaerosyllis hystrix Claparède

Sphaerosyllis hystrix Claparède, 1863, p. 45, pl. 13, figs. 36–37.—Berkeley and Berkeley, 1948, p. 80, fig. 119.—Hartman, 1961, p. 16.—Pettibone, 1963, pp. 136–137, fig. 35g.

MATERIAL.—Stations 9(6), 12(15), 16(12), 19(2), 20(1), 21(1), 22(150), 27(1).

DISTRIBUTION.—British Columbia to southern California, Connecticut, Europe.

Typosyllis fasciata (Malmgren)

Syllis fasciata Malmgren, 1867, p. 43, pl. 8, fig. 47.—Berkeley and Berkeley, 1948, pp. 74–75, figs. 109–110.

Syllis (*Typosyllis*) *fasicata*.—Pettibone, 1954, pp. 254–255, figs. 28 c-e.

Typosyllis fasicata (Malmgren).—Imajima and Hartman, 1964, pp. 135–136, pl. 33, figs. j-o.

MATERIAL.—Station 11(3).

DISTRIBUTION.—North Atlantic Arctic, Japan, China, Alaska south to southern California.

Family Nereidae

Nereis latescens Chamberlin

Nereis latescens Chamberlin, 1919, pp. 10–11.—Hartman, 1961, p.18.

MATERIAL.—Station 11(1).

DISTRIBUTION.—Central and southern California.

Nereis procera Ehlers

Nereis procera Ehlers, 1868, p. 557–559, pl. 23, fig. 2.—Reish, 1959b, pp. 81–82.

MATERIAL.—Station 24(2).

DISTRIBUTION.—Alaska to southern California.

Platynereis bicanaliculata (Baird)

Nereis bicanaliculata Baird, 1863, p. 109.

Platynereis bicanaliculata.—Hartman, 1954b, pp. 36–39, figs. 38–39.—Reish, 1963b, p. 424.

MATERIAL.—Stations 7(6), 8(6), 9(9), 10(3), 11(25), 12(1), 15(53), 18(7), 21(46), 22(6), 24(24), 26(9), 27(1), 29(1).

DISTRIBUTION.—Northeast Pacific Ocean from British Columbia to Baja California, Hawaii, Australia.

Family Nephtyidae

Nephtys caecoides Hartman

Nephtys caecoides Hartman, 1938b, pp. 148–149, fig. 63; 1950, pp. 101–102.

MATERIAL.—Stations 13(4), 17(1), 20(3), 22(2).

DISTRIBUTION.—British Columbia to Baja California.

Family Lumbrineridae

Lumbrineris zonata (Johnson)

Lumbriconereis zonata Johnson, 1901, pp. 408–409, pl. 9, figs. 93–100.
Lumbrineris zonata (Johnson).—Hartman, 1944a, pp. 146–147.

MATERIAL.—Stations 7(3), 8(1), 9(11), 10(21), 11(8), 12(1), 16(8), 17(2).

DISTRIBUTION.—Washington to Baja California.

Family Dorvilleidae

Stauronereis articulatus Hartman

Stauronereis articulatus Hartman, 1938a, pp. 101–102.
Dorvillea articulata Hartman, 1944a, p. 189.—Reish, 1963b, p. 426.

MATERIAL.—Stations 9(1), 10(3), 15(3), 16(2), 18(3), 21(1), 22(6), 24(4).

DISTRIBUTION.—Central California to Baja California.

REMARKS.—*Stauronereis* Verrill (1900) was re-established by Pettibone (1961). Pettibone (1963) placed *S. articulatus* in synonymy with *S. rudolphi* (Delle Chiaje), but we are retaining the name *S. articulatus* for the eastern Pacific population until detailed comparisons can be made with collections from European waters.

Family Orbiniidae

Haploscoloplos pugettensis (Pettibone)

Scoloplos elongata Johnson, 1901, pp. 412–413, pl. 10, figs. 105–110.
Haploscoloplos elongatus (Johnson).—Hartman, 1944b, p. 257; 1957, pp. 273–275, pl. 26, figs. 1–11.—Reish, 1963b, p. 426.
Scoloplos (*Scoloplos*) *pugettensis* Pettibone, 1957, p. 162.

MATERIAL.—Stations 11(3), 16(1), 17(2), 20(2).

DISTRIBUTION.—Alaska to Baja California.

REMARKS.—*Scoloplos elongata* Johnson, 1901, is a junior homonym of *S. elongata* Quatrefages, 1866. Pettibone (1957) renamed Johnson's species as *S.* (*Scoloplos*) *pugettensis*. Earlier Hartman (1944b) referred *S. elongata* Johnson to the genus *Haploscoloplos* Monro, 1933, because of the absence of thoracic uncini in this genus. Pettibone, in 1954 (p. 279) and again in 1957 (p. 160) indicated the difficulty in separating worn thoracic capillary setae in the genus *Haploscoloplos* from the thoracic uncini of the genus *Scoloplos*. This viewpoint was not followed by Hartman (1957) nor Berkeley and Berkeley (1958). We are therefore retaining the new name given by Pettibone, as required by the rules of nomenclature, and placing the species in the genus *Haploscoloplos*.

Scoloplos acmeceps Chamberlin

Scoloplos acmeceps Chamberlin, 1919, pp. 15–16.—Hartman, 1957, pp. 282–283, pl. 30, figs. 1–7.

MATERIAL.—Stations 7(1), 8(1), 9(13), 10(81), 11(2), 19(2).

DISTRIBUTION.—Alaska south to Mazatlán, Mexico.

Family Spionidae

Nerinides acuta (Treadwell)

Spio acuta Treadwell, 1914, pp. 199–201, pl. 11, figs. 14–20.

Nerinides acuta (Treadwell).—Hartman, 1941, pp. 294–296, pl. 45, figs. 1–8; pl. 47, fig. 29; 1954a, p. 10.

MATERIAL.—Stations 9(3), 10(45), 11(4), 12(1), 19(2), 22(15), 23(2), 27(6), 29(1).

DISTRIBUTION.—Central and southern California.

Boccardia uncata Berkeley

Boccardia uncata Berkeley, 1927, p. 418, pl. 1, figs. 9–13.—Hartman, 1961, p. 28.

Polydora (*Boccardia*) *uncata*.—Berkeley and Berkeley, 1952, pp. 14–15, figs. 18–21.—Reish, 1963b, p. 427.

MATERIAL.—Stations 15(1), 16(23), 23(14), 24(10), 27(2).

DISTRIBUTION.—British Columbia to Baja California.

Boccardia polybranchia (Haswell)

Polydora polybranchia Haswell, 1885, p. 275.

Polydora (*Boccardia*) *polybranchia*.—Berkeley and Berkeley, 1952, pp. 16–17, figs. 24–25.—Reish, 1959b, p. 38.

Boccardia polybranchia (Haswell).—Hartman, 1959, p. 375.

MATERIAL.—Station 25(130).

DISTRIBUTION.—Europe, Japan, Australia, British Columbia, and central and southern California.

Polydora ligni Webster

Polydora ligni Webster, 1879, p. 119.—Hartman, 1941, pp. 309–310, pl. 48, figs. 47–49.—Berkeley and Berkeley, 1952, p. 19, figs. 31–33.

MATERIAL.—Stations 15(3), 21(2), 25(3), 27(14), 28(192), 30(33).

DISTRIBUTION.—Both sides of United States, British Columbia, Mexico.

Prionospio cirrifera Wiren

Prionospio cirrifera Wiren, 1883, p. 409.—Berkeley and Berkeley, 1952, pp. 28–29, figs. 52–53.

MATERIAL.—Stations 23(1), 25(1).

DISTRIBUTION.—Europe, Arctic, India, Bering Sea to southern California.

Prionospio pygmaeus Hartman

Prionospio pygmaeus Hartman, 1961, pp. 93–95.—Reish, 1963b, p. 427.

MATERIAL.—Stations 10(1), 15(1).

DISTRIBUTION.—This species was known previously only from southern California and Baja California.

***Pseudopolydora kempi* (Southern)**

Polydora (*Carazzia*) *kempi* Southern, 1921 p. 636, pl. 28, fig. 20.—Fauvel, 1953, pp. 317–318, fig. 167 a-c.—Chlebovitsch, 1961, pp. 199–200.
Polydora kempi.—Day, 1957, pp. 99–100.
Pseudopolydora kempi (Southern).—Hartman, 1959, p. 387.

MATERIAL.—Stations 10(44), 13(1), 17(1), 18(3), 19(2), 22(74), 25(1), 26(25), 27(29), 29(84), 30(2).

DISTRIBUTION.—India, Japan, Kurile Islands, and South Africa. This is the first report of the species from the eastern Pacific Ocean.

***Spiophanes missionensis* Hartman**

Spiophanes missionensis Hartman, 1941, pp. 296–298, pl. 46, figs. 17–21.—Reish, 1963b, p. 427.

MATERIAL.—Station 12(1).

DISTRIBUTION.—Known previously from southern California to Baja California.

***Streblospio benedicti* Webster**

Streblospio benedicti Webster, 1879, pp. 120–121.—Hartman, 1944b, p. 260; 1945, p. 34, pl. 6, fig. 4.

MATERIAL.—Stations 11(2), 12(45), 13(33), 14(3), 19(6), 21(5), 22(216), 23(2), 25(1), 26(437), 27(740), 28(43), 29(255), 30(211).

DISTRIBUTION.—New Jersey, Massachusetts, North Carolina, central and southern California.

Family Magelonidae

***Magelona ?papillicornis* (Müller)**

?Magelona papillicornis (Müller).—fide Fauvel, 1927, pp. 64–65, fig. 22 a–k.

MATERIAL.—Station 4(1).

REMARKS.—This specimen comes closest to *M. papillicornis* (fide Fauvel, 1927), but since only one worm in poor condition was collected and since it has not been reported previously from the Pacific Ocean, it is referred to this species with reservation.

Family Cirratulidae

***Cossura longocirrata* Webster and Benedict**

Cossura longocirrata Webster and Benedict, 1887, p. 743.—Berkeley and Berkeley, 1956, pp. 544–545.—Reish, 1965, p. 145.

MATERIAL.—Stations 12(41), 13(30), 26(1).

DISTRIBUTION.—North Atlantic, Maine, Russian Pacific, Bering and Chukchi Seas, and Washington. This record of the species from Morro Bay is a southern extension of its distribution in the eastern Pacific Ocean.

Family Ctenodrilidae

Ctenodrilus serratus (Schmidt)

Parthenope serratus Schmidt, 1857, p. 363, pl. 5, fig. 13.
Ctenodrilus serratus (Schmidt).—Fauvel, 1927, pp. 108–109, figs. 38a-e.—Hartman, 1961, p. 32.

MATERIAL.—Stations 11(2), 26(2).

DISTRIBUTION.—Cosmopolitan.

Family Ophelidae

Armandia bioculata Hartman

Armandia bioculata Hartman, 1938a, pp. 105–106, figs. 51–54.—Reish, 1963b, p. 428.

MATERIAL.—Stations 3(1), 7(62), 8(29), 9(78), 10(4), 11(9), 18(3), 19(1), 20(2), 21(1), 22(12), 26(11).

DISTRIBUTION.—Northern California to Baja California.

Family Capitellidae

Capitella capitata (Fabricius)

Lumbricus capitatus Fabricius, 1780, p. 279.
Capitella capitata (Fabricius).—Hartman, 1947, pp. 404–405, pl. 43, figs. 1–2.

MATERIALS.—Stations 7(166), 8(149), 10(1), 13(3), 18(179), 21(5), 22(25), 23(11), 24(2), 25(27), 26(190), 27(1628), 28(14), 29(5), 30(29).

DISTRIBUTION.—Cosmopolitan.

Heteromastus filiformis (Claparède)

Capitella filiformis Claparède, 1864, p. 509, pl. 4, fig. 10.
Heteromastus filiformis (Claparède).—Hartman, 1947, pp. 427–428, pl. 52, figs. 1–4.

MATERIAL.—Stations 8(42), 9(32), 10(181), 11(89), 12(23), 13(34), 14(1), 16(3), 17(44), 18(34), 19(101), 21(1), 22(173), 23(1), 25(5), 26(26), 29(288).

DISTRIBUTION.—Widely distributed in both hemispheres.

Family Maldanidae

Axiothella rubrocincta (Johnson)

Clymenella rubrocincta Johnson, 1901, pp. 418–419, pl. 13, figs. 128–133.
Axiothella rubrocincta (Johnson).—Berkeley and Berkeley, 1952, pp. 51–52, figs. 105–106.—Reish, 1963b, p. 429.

MATERIAL.—Stations 18(1), 20(1), 22(89).

DISTRIBUTION.—British Columbia to Baja California.

Family Terebellidae

Pista alata Moore

Pista (*Scionopsis*) *alata* Moore, 1909, pp. 273–275, pl. 9, figs. 48–51.
Pista alata.—Reish, 1963b, p. 430.

MATERIAL.—Stations 9(2), 12(1), 13(1), 15(15), 18(125), 20(1), 21(6), 22(31).

DISTRIBUTION.—Heretofore known only from southern California and San Quintin Bay, Baja California.

Family Sabellidae

Chone infundibuliformis Kröyer

Chone infundibuliformis Kröyer, 1856, p. 33.—Berkeley and Berkeley, 1952, p. 133, figs. 252–253.—Pettibone, 1954, pp. 338–339, figs. 39a–j.

MATERIAL.—Stations 7(7), 10(38), 11(29), 12(1), 14(2), 17(7), 18(1), 19(39), 20(69), 22(4).

DISTRIBUTION.—North Atlantic, Arctic, British Columbia, California.

Family Serpulidae

Subfamily Spirorbinae

MATERIAL.—Stations 12(3), 15(512), 16(3).

REMARKS.—No attempt was made to identify these specimens. Many were observed attached to blades of the eel grass *Zostera marina*.

The Amphipod Fauna

In contrast to the other well-known bays of the Californias, Bahía de San Quintín and Newport Bay, the amphipod fauna of Morro Bay is characterized by several boreal elements and by a few species associated with brackish water. Although the waters of Morro Bay were not brackish at the time of this survey, the presence of *Corophium spinicorne* and the abundance of *C. uenoi* and *C. acherusicum* suggest a history of dilution. Of course these species may also be linked with environments which are abnormal in factors other than dilution, such as natural and artificial pollution and wide ranges in thermal regime. The boreal elements known to occur in the Morro Bay fauna, such as *Ampithoe lacertosa*, *Allorchestes angustus*, *Aoroides columbiae*, *Pontogeneia rostrata*, *Ampithoe valida*, and possibly *Eohaustorius washingtonianus*, which are lost or diminished in Newport Bay (Barnard, 1959) and Bahía de San Quintín (Barnard, 1964), may not be due so much to the supposed increase in average temperatures of the southern bays as they are to the greater yearly range of temperatures there.

An analysis of the ecological and zoogeographical distribution of the amphipod species encountered showed that all of the species have been derived from the open sea, or have had to find a pathway through it. Of all species encountered, *Corophium spinicorne* is the most firmly bound to estuarine conditions. Those species that are considered as primarily of estuarine habit, because of the absence or near absence of

their populations in the open sea at these latitudes, include *Corophium uenoi*, *Allorchestes angustus*, *Elasmopus rapax* (sensu stricto), *Ampithoe valida*, *Pontogeneia minuta*, and *Ampithoe longimana*. These are primarily confined to the innermost reaches of the bay, in or near marshland channels. Generally, they are also among the most abundant species of any of the samples, as the following ranked list of species and numbers of individuals in 26 samples shows: *Corophium uenoi* (1131), *Aoroides columbiae* (808), *Corophium spinicorne* (333), *Ampithoe lacertosa* (242), *Microdeutopus schmitti* (205), *Pontogeneia rostrata* (194), *Corophium acherusicum* (187), *Allorchestes angustus* (116). Note, however, that *Elasmopus rapax*, *Ampithoe valida*, *Pontogeneia minuta*, and *Ampithoe longimana* are rare in these samples. The discontinuity of many of the typical open-sea species from the sea to the inner reaches of Morro Bay is probably due to the unsuitable, coarse, sandy substrates, rapid tidal currents and lack of benthic algae at the seaward stations.

Species and genera known to occur in Bahía de San Quintín (table 2) that were not discovered in Morro Bay and that are considered to be absent because of geographic thermal differences are: *Acuminodeutopus*, *Rudilemboides*, *Lemboa macromanus*, *Amphideutopus*, *Orchomene magdalenensis*, and *Pontogeneia quinzana*.

Other San Quintin species that, in the open sea, extend to the north of Morro Bay and probably are excluded from the estuary for reasons other than thermal structure are *Ampelisca compressa* and *Hyale frequens*. The absence of both species is striking and unexplainable.

The most unusual difference between Bahía de San Quintín and Morro Bay is in the species of *Ampelisca* that dominate the benthos; in San Quintin *Ampelisca compressa* is the dominant; this species occurs northward in the open sea to Puget Sound, Washington, but in Morro Bay (and in Tomales Bay, material at hand), the principal species is *A. cristata*. Both *A. compressa* and *A. cristata*, however, are known to occur in tropical Pacific and tropical Atlantic America, so that neither can be considered a warm or a cool-sea species. Other species of *Ampelisca* occur only incidentally in Newport Bay.

Although the plant is widespread in Morro Bay, stands of the eel-grass, *Zostera marina*, do not seem as dense in Morro Bay as in Bahía de San Quintín. That eel-grass is not so prominent in Morro Bay as in San Quintin is shown by the absence or low rank of *Hyale*, *Pontogeneia*, and *Erichthonius*, genera of amphipods which characterize the San Quintin eel-grass beds (Barnard, 1964). On the other hand, a relatively higher incidence of algae is indicated in Morro Bay by the high rankings of *Corophium*, *Aoroides*, and *Ampithoe*.

The influence of the dense populations associated with pilings in Newport Bay is now confirmed in comparing the fauna of that bay

with that of San Quintin Bay and Morro Bay. The bottom fauna at Newport has a number of highly ranked species (table 2) that apparently represent extravagants from the piling fauna: *Leucothoides pacifica*, *Colomastix pusilla*, *Jassa falcata*, and both species of *Podocerus*.

TABLE 2.—Dominant amphipods listed by rank according to their frequencies in Morro Bay, Newport Bay, and Bahía de San Quintín

Morro Bay (herein)	Newport Bay (Barnard, 1959, 1961)	Bahía de San Quintín (Barnard, 1964)
Corophium uenoi	*Elasmopus rapax*	*Ampelisca compressa*
Aoroides columbiae	*Acuminodeutopus heteruropus*	*Ericthonius brasiliensis*
Corophium spinicorne	*Rudilemboides stenopropodus*	*Rudilemboides stenopropodus*
Ampithoe lacertosa	*Ampithoe plumulosa* [1]	*Acuminodeutopus heteruropus*
Microdeutopus schmitti	*Ampithoe pollex*	*Hyale frequens* (as *nigra*)
Pontogeneia rostrata	*Leucothoides pacifica*	*Aruga holmesi*
Corophium acherusicum	*Corophium acherusicum*	*Microdeutopus schmitti*
Allorchestes angustus	*Corophium baconi*	*Paraphoxus obtusidens*
Heterophoxus oculatus	*Hyale frequens*	*Lembos macromanus*
Ampelisca cristata	*Paraphoxus spinosus*	*Amphideutopus oculatus*
Photis brevipes	*Ericthonius brasiliensis*	*Orchomene magdalenensis*
Synchelidium shoemakeri	*Colomastix pusilla*	*Corophium uenoi*
Elasmopus rapax	*Amphideutopus oculatus*	*Listriella melanica*
Ampithoe valida	*Corophium uenoi*	*Elasmopus rapax*
Synchelidium rectipalmum	*Amphilochus neapolitanus*	*Uristes entalladurus*
Batea transversa	*Maera simile*	*Corophium baconi*
Paraphoxus stenodes	*Microdeutopus schmitti*	*Pontogeneia quinsana*
Pontogeneia minuta	*Jassa falcata*	*Corophium acherusicum*
Ampithoe longimana	*Podocerus brasiliensis*	*Paraphoxus heterocuspidatus*
Corophium baconi	*Podocerus fulanus*	*Ampithoe plumulosa*

[1] Table 1 of Barnard (1961) entry "4" should read *Ampithoe plumulosa* not *A. pollex*.

Family Ampeliscidae

Ampelisca cristata Holmes

Ampelisca cristata Holmes, 1908, pp. 507–508, figs. 16, 17.—Barnard, 1954a, pp. 26–29, pls. 17–18; 1959, p. 18.

MATERIAL.—Stations 10(1), 12(14), 20(5), 21(10), 22(2), 25(3).

DISTRIBUTION.—Caribbean Sea; eastern Pacific from Ecuador to Tomales Bay, Calif.

Family Ampithoidae

Ampithoe lacertosa Bate

Ampithoe lacertosa Bate, 1858, p. 362.—Gurjanova, 1951, pp. 895–897, fig. 622.—Barnard, 1954b, pp. 31–33, pls. 29–30.—Nagata, 1960, pp. 175–176, pl. 16, figs. 95–96.

MATERIAL.—Stations 9(29), 16(206), 18(7).

DISTRIBUTION.—Japan; Kodiak, Alaska to Magdalena Bay, Baja California.

Ampithoe longimana Smith

Ampithoe longimana Smith, 1873, pp. 563–564.—Barnard, 1959, pp. 36–37, pl. 12; 1964, p. 111.

MATERIAL.—Stations 9(1), 21(4).

DISTRIBUTION.—Atlantic coast of the United States and Bermuda; eastern Pacific Ocean only in bays (Morro Bay, Newport Bay, Bahía de San Quintín).

Ampithoe valida Smith

Ampithoe valida Smith, 1873, p. 563.—Barnard, 1954b, pp. 34–35, pl. 31.—Nagata, 1960, p. 176, pl. 16, figs. 97, 98.

MATERIAL.—Stations 26(6), 28(4).

DISTRIBUTION.—Atlantic coast of United States; Japan; eastern Pacific Ocean from Coos Bay, Oreg., to Morro Bay.

Family Aoridae

Aoroides columbiae Walker

Aoroides columbiae Walker, 1898, p. 285, pl. 16, figs. 7–10.—Barnard, 1954b, pp. 24–26, pl. 22; 1959, p. 33.—Nagata, 1960, p. 175, pl. 16, fig. 94.—Barnard, 1961, p. 180; 1964, p. 110.

MATERIAL.—Stations 7(15), 8(10), 9(473), 10(34), 15(8), 18(266), 21(1), 23(1).

DISTRIBUTION.—Puget Sound to Bahía de San Quintín, Baja California.

Microdeutopus schmitti Shoemaker

Microdeutopus schmitti Shoemaker, 1942, pp. 18–21, fig. 6.—Barnard 1959, pp. 32–33, pl. 9; 1961, p. 180; 1964, p. 110, chart 13.

MATERIAL.—Stations 15(114), 21(52), 24(39).

DISTRIBUTION.—Monterey Bay to Cape San Lucas, Baja California.

Family Bateidae

Batea transversa Shoemaker

Batea transversa Shoemaker, 1926, pp. 13–18, figs. 8–11.

MATERIAL.—Stations 15(5), 18(1).

DISTRIBUTION.—Southern California at Morro Bay, Catalina Island, and Point Loma.

Family Corophiidae

Corophium acherusicum Costa

Corophium acherusicum Costa, 1857, p. 232.—Shoemaker, 1947, p. 53, figs. 2, 3; 1949, p. 76.—Barnard, 1954b, p. 36; 1959, p. 38; 1961, p. 182; 1964, p. 111, chart 5.

MATERIAL.—Stations 9(1), 15(5), 16(143), 21(1), 23(37).

DISTRIBUTION.—Cosmopolitan in temperate and tropical waters, especially in bays and harbors.

Corophium baconi Shoemaker

Corophium baconi Shoemaker, 1934, pp. 356–359, fig. 1; 1949, p. 82.—Barnard, 1959, p. 38; 1961, p. 182; 1964, pp. 111–112, chart 16.

MATERIAL.—Station 15(4).

DISTRIBUTION.—Peru to the Bering Sea.

Corophium spinicorne Stimpson

Corophium spinicorne Stimpson, 1857, pp. 514–515.—Shoemaker, 1949, pp. 74–76, fig. 6.—Barnard, 1952, p. 33; 1954b, pp. 36–37.

MATERIAL.—Stations 26(327), 27(5), 28(1).

DISTRIBUTION.—Alaska to Morro Bay, Calif.

Corophium uenoi Stephensen

Corophium uenoi Stephensen, 1932, pp. 494–498, figs. 3, 4.—Barnard, 1952, pp. 28–32, pls. 8, 9; 1959, p. 39.—Nagata, 1960, p. 178.—Barnard, 1961, p. 183; 1964, p. 112, chart 16.

MATERIAL.—Stations 16(260), 17(3), 21(2), 22(1), 23(31), 26(18), 27(291), 28(517), 29(4), 30(4).

DISTRIBUTION.—Japan; Morro Bay to Bahía de San Quintín in the Californias.

Ericthonius sp. [cf. *brasiliensis* (Dana)]

MATERIAL.—Station 27 (1 juv.). Probably this specimen is the juvenile of *E. brasiliensis*. See Sars (1895, pl. 215) for illustration and Barnard (1959 and 1964) for references and distribution of this species.

DISTRIBUTION.—Cosmopolitan (except in polar regions) in bays and harbors and the open-coast intertidal.

Family Eusiridae

Pontogeneia minuta Chevreux

Pontogeneia minuta Chevreux, 1908, pp. 1–3, fig. 1.—Barnard, 1959, p. 23, pl. 3; 1964, p. 106, figs. 21 B, C.

MATERIAL.—Stations 26(4), 27(1).

DISTRIBUTION.—In the Pacific found in Morro Bay, Newport Bay, and Bahía de San Quintín, Baja California. The identification of the Pacific forms with Chevreux's species is open to question.

***Pontogeneia rostrata* Gurjanova**

Pontogeneia rostrata Gurjanova, 1938, p. 386, fig. 84.—Barnard, 1962b, p. 5.

MATERIAL.—Stations 4(1), 9(27), 10(21), 15(5), 18(7).

DISTRIBUTION.—Bering Sea, Okhotsk Sea, Japan Sea to Bahía de San Quintín, Baja California.

Family Gammaridae

***Elasmopus rapax* Costa**

Elasmopus rapax Costa, 1853, p. 171.—Bate, 1862, pp. 521, 522, pl. 92, fig. 6.—Stebbing, 1906, p. 512, pl. 92.—Shoemaker, 1942, p. 12.—Barnard, 1958, pp. 26, 28, 1962b, pp. 44, 46, figs. 18, 19, 1964, p. 108, chart 9.

MATERIAL.—Stations 27(9), 28(1).

DISTRIBUTION.—Pantropical with penetration to warm-temperate and rarely cold-temperate waters in the northeastern Atlantic. This is a bay form; however, an open-sea California form has been described by Barnard (1962b).

Family Haustoriidae

***Eohaustorius washingtonianus* (Thorsteinson)**

Haustorius washingtonianus Thorsteinson, 1941, pp. 81, 82, pl. 4, figs. 36, 37.
Eohaustorius washingtonianus Barnard, 1955, p. 22, pl. 14.—Gurjanova, 1962, pp. 404–405, fig. 135.

MATERIAL.—Station 4(2).

DISTRIBUTION.—Puget Sound to just southeast of Point Conception, Calif.

Family Hyalidae

***Allorchestes angusta* Dana**

Allorchestes angusta Dana, 1856, p. 177.—Barnard, 1962, pp. 20–22, pl. 1, figs. 2–4, 1954a, pp. 21–23, pl. 21, 1958, p. 22.

MATERIAL.—Stations 18(33), 25(77), 27(3).

DISTRIBUTION.—Japan; Coos Bay, Oreg., to Newport Bay, Calif.

Family Ischyroceridae

***Jassa falcata* (Montagu)**

Jassa falcata (Montagu).—Sexton and Reid, 1951, pp. 36–47, pls. 4–9 (with synonymy).—Barnard, 1955, p. 37, 1958, p. 112.

MATERIAL.—Station 9(1).

DISTRIBUTION.—Cosmopolitan in cold-temperate and tropical waters, especially in bays and harbors.

Family Oedicerotidae

Synchelidium rectipalmum Mills

Synchelidium rectipalmum Mills, 1962, pp. 17–19, fig. 5.

MATERIAL.—Stations 15(3), 21(4), 22(1).

DISTRIBUTION.—British Columbia to middle Baja California.

Synchelidium shoemakeri Mills

Synchelidium shoemakeri Mills, 1962, pp. 15–17, fig. 4.

MATERIAL.—Stations 7(1), 14(1), 20(10).

DISTRIBUTION.—British Columbia to middle Baja California.

Family Photidae

Photis brevipes Shoemaker

Photis brevipes Shoemaker, 1942, pp. 25–27, fig. 9.—Barnard, 1962a, pp. 31–33, fig. 11.

MATERIAL.—Stations 7(1), 8(2), 9(24), 12(3), 18(3).

DISTRIBUTION.—Coos Bay, Oreg., to Magdalena Bay, Baja California.

Family Phoxocephalidae

Heterophoxus oculatus (Holmes)

Harpinia oculata Holmes, 1908, pp. 521–523, fig. 28.

Heterophoxus oculatus (Holmes).—Barnard, 1960, pp. 320–324, pls. 59–61; 1964, p. 102.

MATERIAL.—Stations 12(5), 15(66), 16(2), 24(25).

DISTRIBUTION.—Puget Sound to Panama, an open-sea deep-water species, 13–1785 meters, occasionally penetrating shallow bays such as Morro Bay and San Quintin Bay.

Paraphoxus epistomus (Shoemaker)

Pontharpinia epistoma Shoemaker, 1938, pp. 326–329, fig. 1.

Paraphoxus epistomus (Shoemaker).—Barnard, 1960, pp. 205–209, pls. 6–8.

MATERIAL.—Station 14(1).

DISTRIBUTION.—Mendocino County, Calif., to Panama; Atlantic Ocean from New Hampshire to South Carolina.

Paraphoxus spinosus Holmes

Paraphoxus spinosus Holmes, 1905, pp. 477–478, fig. 12.—Barnard, 1959, p. 18; 1960, pp. 243–249, pls. 29–31; 1964, p. 105.

MATERIAL.—Station 14(1).

DISTRIBUTION.—Western Atlantic Ocean; Pacific Ocean from Puget Sound to the Gulf of California.

***Paraphoxus stenodes* Barnard**

Paraphoxus stenodes Barnard, 1960, pp. 221–224, pls. 17, 18.

MATERIAL.—Stations 4(2), 14(1), 20(2).

DISTRIBUTION.—Point Conception, Calif., to San Cristobal Bay, Baja California.

Miscellaneous Amphipod Specimens

***Ampithoe* species, juveniles**

MATERIAL.—Stations 9(9), 10(1), 15(5), 17(1), 23(1), 24(1), 27(2).

***Corophium* species, juveniles**

MATERIAL.—Stations 7(2), 9(1), 16(10), 18(1), 21(1), 23(3), 24(1), 27(32), 28(36).

***Ericthonius* species, juveniles**

MATERIAL.—Station 27(1).

***Photis* species, juveniles**

MATERIAL.—Stations 10(2), 15(3).

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